Charging behaviour in persistent phosphors

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During the excitation of a persistent phosphor, the intensity of the luminescence does not immediately jump to a constant value. Instead, it rises gradually during several seconds or minutes before reaching its final value. This phenomenon is caused by the competition between trap filling on one hand, and luminescence on the other hand. The more the excited electrons are being trapped, the less they are available for luminescence. Hence, in the beginning of the excitation process, when nearly all traps are empty, the trapping process dominates the luminescence, and the intensity of the emitted light will be low. Clearly, the charging behaviour is closely related to the traps present in the material.

It is, therefore, surprising that so little investigations on charging behaviour have been reported [1-3]. These charging curves can learn us more about the amount and density of the traps, the rate at which electrons (or holes) are being caught, the trap depth, and possibly even their nature and origin. In fact, the luminescence during charging is closely related to the afterglow of the phosphor, the only difference being the presence of an external excitation source. Hence, we can expect to learn at least as much from charging behaviour as there is to learn from afterglow intensity.

We investigated the charging behaviour in the well-known $SrAl_2O_4$:Eu,Dy and $CaAl_2O_4$:Eu,Nd phosphors, as a function of the excitation source, duration, and intensity. These measurements were combined with afterglow and thermoluminescence measurements to study the amount of traps being filled. The charging curves under intense laser radiation, where the luminescence is practically saturated, were also measured, to investigate the concentrations of traps and activators present in the material.

We will present some simple models for the involved processes, with greatly simplified assumptions, in order to explain some of the observed charging features.

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